IN THE SPECIFICATION

Please delete paragraph [0002] and replace with the following paragraph:

A highly uniform magnetic field is useful for nuclear resonance image (MRI) and nuclear magnetic resonance (NMR) systems as medical devices or chemical/biological devices. Most popular systems currently available worldwide use a superconducting magnet system which creates a highly uniform field in a pre-determined space (imaging volume). A superconducting magnet system usually uses multiple superconducting coils (main coil system) to achieve a desired ~~high~~ highly uniform magnetic field in the imaging volume. More advanced superconducting MRI and NMR magnet systems also use an active shielding technique which adds a second set of multiple coils (shielding coil system) which creates a reverse direction magnetic field to reduce the fringe magnetic field and to achieve a significant reduction of the external magnetic field in the surrounding space of the magnet system. Depending on the design, the main coils system and shielding coils system can use a single circuit running the same electrical current, or two individual circuits running either the same current or two different currents. From the laws of physics, one knows that for a single superconductive closed loop, the total magnetic flux inside of the loop does not change. ~~However,~~ However, for a multi-coil system, especially for an actively shielded MRI magnet system with main coils and shielding coils connected in series, the situation is a little different.

Please delete paragraph [0003] and replace with the following paragraph:

Due to the environment disturbances, such as a train and/or other moving vehicles, rotating machinery, ~~elevators~~ elevators, etc, in the surrounding area, the magnetic field of the system will have a corresponding temporal magnetic flux change. Practically, all magnet systems are subject to such temporal field instability ranging from ppm (parts per million) to ppb (parts per billion). But for actively shielded magnet systems, this change is more severe. For good image quality, the temporal field variation of a typical MRI should normally be less than

0.05 to 0.1 ppm/hour. The stability of the magnet center field is, however, highly affected by the environment disturbances, especially for those actively shielded magnets. The magnitude of the field fluctuations depends on both the size of the object and the distance away from the magnet system. For example, a typical elevator 20 feet away from the magnet can cause a field fluctuation of about 0.01 Gauss or 1.0E-6 Tesla, a subway can also cause a 0.1 Gauss field fluctuation.

Please delete paragraph [0004] and replace with the following paragraph:

Clearly, these environment disturbances induced changes in both center magnetic field and its homogeneity will cause detectable deviation of the nuclear imaging quality (imaging distortion) for MRI and NMR ~~device~~ devices.

Please delete paragraph [0005] and replace with the following paragraph:

In order to minimize such ~~effect~~ effects caused by environment changes and other disturbances, the electrical currents changing in both main coils and shielding coils should be controlled or limited to some prescribed acceptable level such that the environment disturbance is compensated and the center magnetic field ~~remain~~ remains constant and uniform. One structure and method has been described in US Patent No. 4926289 for such purpose by using a single filament or a few filaments of superconducting wire for the purpose of having low critical current. However, it would be desirable to provide methods and apparatus which are not constrained to filament(s) with low critical current.

Please delete paragraph [0006] and replace with the following paragraph:

In one aspect, a method of operating an imaging system having a main coil and a shield coil electromagnetically coupled to the main coil is provided. The method includes monitoring for an external environmental fluctuation of electromagnetism, and controlling current flow ~~though~~ through the main and shield coils based upon the monitoring using a quench heater.

Please delete paragraph [0007] and replace with the following paragraph:

In another aspect, an imaging system includes a main coil, a shield coil positioned to shield an electromagnetic ~~filed~~ field generated by the main coil, and at least one environmental fluctuation circuit operationally coupled to at least one of the main coil and the shield coil, the circuit including at least one detection coil, and a quench heater positioned proximate the detection coil.

Please delete paragraph [0008] and replace with the following paragraph:

In a further aspect, a method of operating an imaging system comprising a main coil, a shield coil positioned to shield an electromagnetic ~~filed~~ field generated by the main coil, and at least one environmental fluctuation circuit operationally coupled to at least one of the main coil and the shield coil, the circuit comprising at least one detection coil, and a quench heater positioned proximate the detection coil is provided. The method includes energizing the quench heater such that the detection coil is in a non-superconductive state, supplying current to the main coil and the shield coil until a predetermined current is reached while the detection coil is in the non-superconductive state, activating a persistence switch to a superconductive state, and ~~de-energize~~ de-energizing the quench heater when the persistence switch is in the superconductive state.

Please delete paragraph [0010] and replace with the following paragraph:

Figure 2 is a schematic diagram of a conventional ~~circuitry of~~ circuitry of a superconducting current limiter for a superconducting MRI, NMR magnet system.

Please delete paragraph [0012] and replace with the following paragraph:

Figure 4 is a schematic diagram of another ~~circuitry of~~ circuitry of the superconducting MRI, NMR magnet system shown in Figure 1 with a detection system.

Please delete paragraph [0020] and replace with the following paragraph:

System control 34 includes a plurality of modules 38 electrically coupled using a backplane (not shown). In the exemplary embodiment, modules 38 include a CPU module 40 and a pulse generator module 42 that is electrically coupled to operator console 12 using a serial link 44. Link 44 facilitates transmitting and receiving commands between operator console 12 and system command 34 thereby allowing the operator to input a scan sequence that MRI system 10 is to perform. Pulse generator module 42 operates the system components to carry out the desired scan sequence, and generates data which indicative of the timing, strength and shape of the RF pulses which are to be produced, and the timing of and length of a data acquisition window. Pulse generator module 42 is electrically coupled to a gradient amplifier system 46 and provides gradient amplifier system 46 with a signal indicative of the timing and shape of the gradient pulses to be produced during the scan. Pulse generator module 42 is also configured to receive patient data from a physiological acquisition controller 48. In the exemplary embodiment, physiological acquisition controller 48 is configured to receive inputs from a plurality of sensors indicative of a ~~patients~~ patient's physiological condition such as, but not limited to, ECG signals from electrodes attached to the patient. Pulse generator module 42 is electrically coupled to a scan room interface circuit 50 which is configured to receive signals from various sensors indicative of the patient condition and the magnet system. Scan room interface circuit 50 is also configured to transmit command signals such as, but not limited to, a command signal to move the patient to a desired position, to a patient positioning system 52.

Please delete paragraph [0025] and replace with the following paragraph:

Figure 3 illustrates a circuitry of MRI system 10 including a two coil detection system 118. MRI system 10 includes a cryogenic temperature cryostat 120 in which a main coil 122, a shielding coil 124, a quench protection system 128, and a superconducting persistent switch 134 are positioned. A power supply 126 is typically positioned outside cryostat 120. Detection system 118 includes an environmental fluctuation circuit 130. In an exemplary embodiment,

main coil 122 and shield coil 124 are wired in series receiving the same current, and environmental fluctuation circuit 130 includes two environmental fluctuation circuits 132, one for main coil 122, and one for shield coil 124. During a magnet system energizing process, persistent switch 134 is in an off mode (i.e., a resistive state). Energy is supplied to main coil 122 and shielding coil 124 from power ~~supply 108~~ <u>supply 126</u> until a desired magnetic field is produced, then persistent switch 134 is switched to an on mode (i.e., a superconductive state). During the just described magnet ramping, a pair of quench heaters (not shown in Figure 3) are turned on, thus the sections of CC'D'D and DD"E'E are resistive and prevent electrical current to flow therethrough, and all electrical current flows through main coil 122 and shielding coil 124. After the magnet (coils 122 and 124) reaches a desired field level, and are shimmed and parked using ~~convention methods. The quench~~ <u>conventional methods, the quench</u> heaters of environmental fluctuation circuits 132 are turned off, and sections CC'D'D and DD"E'E return to a superconductive state. When an outside disturbance is present, both electrical currents in main coil 122 and shield coil 124 may start to change. Since coils 122 and 124 and environmental fluctuation circuits 132 are in the same circuit, any induced current flows through either CC'D'D, or DD'E'E circuit, or both circuits. Thus with the ~~aid of~~ <u>aid of a</u> detection and controlling scheme identical or similar to that illustrated in Figure 5, currents I_c and I_d are detected, limited, and/or controlled as explained below in greater detail.

Please delete paragraph [0026] and replace with the following paragraph:

Figure 4 illustrates a one coil detection system 150 in which MRI system 10 includes a cryogenic temperature cryostat 152 in which a main coil 154, a shielding coil 156, a quench protection system 158, and a superconducting persistent switch 160 are positioned. A power supply 161 is typically positioned outside cryostat 152. System 150 also includes an environmental fluctuation circuit 162. In an exemplary embodiment, main coil 154 and shield coil 156 are wired in series receiving the same current, and environmental fluctuation circuit 162 is wired in parallel to one of main coil 154 and shielding coil 156. As illustrated in Figure 4, environmental fluctuation circuit 162 is wired in parallel to main coil 154. When electrical

current I_a and I_b are not equal due to outside electromagnetic disturbances, the differential current of main coils I_a and shielding coils I_b flows through superconducting circuit CC'D'D, thus with the ~~aid of~~ aid of a detection and controlling scheme identical or similar to that illustrated in Figure 6, a differential current I_c is detected, limited, and/or controlled. Although Figure 4 illustrates that superconducting wire is connected to main coil 154 at ~~point~~ points C and D in Figure 4, the superconducting wire alternatively can be connected to shield coil 156 similarly, or be connected to the points within the coil. For example, in Figure 4 points C and D are located at a plurality of edges of coil 154, points C and D may be located within coil 154 and coil 156 respectively (i.e., points C and/or D are located in a coiled section of coil(s) 154 and/or 156). The exact position of points C and D for example depends entirely on a particular magnet design and the requirements for environment disturbance compensation. Figure 5 through Figure 8 explain in additional detail how to detect these induced currents and how to control/eliminate these currents.

Please delete paragraph [0028] and replace with the following paragraph:

Figure 6 illustrates a single coil detection system 190 including a quench heater power supply 192 coupled to a quench heater 194 and a sensor 196 via a switch 198. When the current in CC'D'D circuit (I_c) starts to flow, and with the aid of detection sensor 196 (either mechanical or electronic as detailed below) and control switch K, quench heater 194 is energized to heat the superconducting wires CC'D'D and cause the superconducting wire to quench when current I_c reaches above a predetermined level (e.g., 2 Amperes), and thus reduce the electrical currents I_c to zero, which forces electrical currents in main coil 154 I_a and shield coil ~~I_b 156~~ 156 $I_b$to be the same. After sensor 196 detects a zero current I_c switch 198 switches off the current in quench heater 194. Thus the electrical currents of main coil 154 and shielding coil 156 are the same again.

Please delete paragraph [0029] and replace with the following paragraph:

Figure 7 is a schematic of a mechanical sensor 200 for detection systems 118 and 150 (e.g., sensors 182 and 196), employed in some embodiments. A power source 201 is coupled to a quench heater 202 via wires 208 to a piston assembly 209. Mechanical sensor 200 includes a solenoid 204 which can be either a bifilar winding (as shown in Figure 4) or a simple winding (as shown in Figure 6). A plurality of mechanical springs 206 regulate a null level and a trigger level to control a metal piston on/off condition. Mounted within piston assembly 209 is a plurality of pistons 210. When no net magnetic field disturbances except original ~~magnet~~ magnetic field created by the main and shielding coils present in solenoid 204, mechanical springs 206 ~~are at~~ are at a pre-set null level, and metal pistons 210 do not contact a stator, and hence, no current goes through the resistive quench ~~heater(s)~~ heater(s) 202. When electrical current reaches a pre-set level (e.g., 2 amps) in solenoid 204 by the environment disturbances, the electromagnetic force on pistons 210 pulls one of the pistons 210 toward the stator, and the quench heater circuit engages, ~~and cause~~ causing the superconducting wires (CC'D'D and/or D'D"E'E) to quench. When the current drops to zero after quench, piston 210 returns to its null position, and the quench circuit is disengaged. In one embodiment, pistons 210 are positioned opposing each other such that current flow in either direction CC'D'D or DD'C'C causes one of pistons 210 to move toward a center of assembly 209 to complete the circuit between power supply 201 and heater 202. In an alternative embodiment, only a single piston 210 is used.

Please delete paragraph [0030] and replace with the following paragraph:

Figure 8 is a schematic of an electronic sensor circuit 220 that is used in detection systems 118 and 150 (e.g., sensors 182 and 196), in some embodiments. Circuit 220 includes a quench heater 222 coupled to a power source 224 via a switch 226. An electronic sensor 228 is positioned within a solenoid 230. Detection sensor 228 is, in one embodiment, a Hall effect element. In an alternative embodiment, sensor 228 is other means of semiconductor elements or a pickup coil. With the presence of electrical current in solenoid 230, a net magnetic field fluctuation is detected by sensor 228. Sensor 228 outputs a related voltage (or a related current) signal to control switch 226 in an on state and an off state. If sensor 228 detects the current in

solenoid 230 reaching a predetermined level, the corresponding output signal triggers switch 226 to close, and thus, current flows through quench ~~heater 22~~ heater 222, which starts to heat the superconducting wire to ~~cause it~~ cause the superconducting wire to quench. When sensor 228 detects a zero current in ~~solenoid 228~~ solenoid 230, switch 226 is opened to ~~deenergize~~ de-energize heater 222 allowing any superconductive wires proximate heater 222 to return to a superconductive state. The predetermined level can be set electronically.

Please delete paragraph [0031] and replace with the following paragraph:

If the main coils and shielding coils operate on different currents, the above ~~describes~~ described detection methods and systems are employable with only a slight modification. For example, with both coils operational electrical currents I_m, I_s known, and with their respective preset current changing limits known, a ratio of the currents $p=(I_m/I_s)$ is determined. Then the number of turns of CC'D'D superconducting wire to the number of turns of DD'E'E superconducting wire can be selected such that (CC'D'D turn number)/(DD'E'E turn number) is equal to p and wound in bifilar fashion, and then the above described methods and apparatus are used to detect environmental disturbances as described above.